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भाग 3 अनुप्रयोग नियामिका

अनुभाग 7 इलैक्ट्रॉनिक हार्डवेयर की रिलाएबिलिटी स्ट्रैस स्क्रीनिंग

Indian Standard

DEPENDABILITY MANAGEMENT

PART 3 APPLICATION GUIDE

Section 7 Reliability Stress Screening of Electronic Hardware

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NEW DELHI 110002

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Reliability of Electronic and Electrical Components and Equipments Sectional Committee, LTD 03

NATIONAL FOREWORD

This Indian Standard (Part 3/Sec 7) is identical with IEC 60300-3-7 (1999) **'Dependability management — Part 3-7 : Application guide — Reliability stress screening of electronic hardware'** issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Reliability of Electronic and Electrical Components and Equipments Sectional Committee and approval of the Electronics and Information Technology Division Council.

The text of the IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their places are given below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60050 (191) (1990) International Electrotechnical Vocabulary (IEV) — Chapter 191 : Dependability and quality of service	IS 1885 (Part 39) : 1999 Electrotechnical vocabulary: Part 39 Reliability of electronic and electrical items (*second revision*)	Technically Equivalent
IEC 61163-1 (1995) Reliability stress screening — Part 1 : Repairable items manufactured in lots	IS 15444 (Part 1) : 2004 Reliability stress screening: Part 1 Repairable items manufactured in lots	Identical

The technical Committee responsible for the preparation of this standard has reviewed the provisions of the following International Standards and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
IEC 60068-2 (all parts)	Environmental testing — Part 2 : Tests
IEC 60747 (all parts)	Semiconductor devices — Discrete devices
IEC 60748 (all parts)	Semiconductor devices — Integrated circuits
IEC 60749 (1996)	Semiconductor devices — Mechanical and climatic test methods
IEC 61163-2 (1998)	Reliability stress screening — Part 2 : Electronic components
ISO 8258 : 1991	Shewhart control charts
MIL STD 750, 2052	Test methods for semiconductor devices, 2000 series test methods
MIL STD 883, 2020	Test methods for microelectronics, 2000 series test methods

Only the English text of the International Standard has been retained while adopting it as an Indian Standard and as such the page numbers given here are not the same as in IEC publication.

IS 15474 (Part 3/Sec 7) : 2005
IEC 60300-3-7 (1999)

Indian Standard

DEPENDABILITY MANAGEMENT

PART 3 APPLICATION GUIDE

Section 7 Reliability Stress Screening of Electronic Hardware

1 Scope

This part of IEC 60300 serves as an application guide to a reliability stress screening process for electronic hardware. The concept, purpose and justification of the screening process are explained. The main elements of a screening programme are stated, together with the general planning procedure. This standard is intended as a guide and should be used in conjunction with one of the IEC reliability stress screening standards, ("tools" in the toolbox concept), referenced in clause 15, based on the screening process application level.

This standard gives guidance in cases where it is essential that early failures be removed from the items manufactured in order to deliver them to the customer when the problems causing the early failures are solved. The standard also gives guidance on where the reliability stress screening should be carried out, i.e. component level, subsystem level, or system level (see figure 1), and can also be used where steps to reduce the risk of early failures are included in a contract.

This standard is aimed at personnel in the contract department, project management, product development, process management, production, quality control and purchasing.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(191):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 191: Dependability and quality of service*

IEC 60068-2 (all parts), *Environmental testing – Part 2: Tests*

IEC 60747 (all parts), *Semiconductor devices – Discrete devices*

IEC 60748 (all parts), *Semiconductor devices – Integrated circuits*

IEC 60749:1996, *Semiconductor devices – Mechanical and climatic test methods*

IEC 61163-1:1995, *Reliability stress screening – Part 1: Repairable items manufactured in lots*

IEC 61163-2:1998, *Reliability stress screening – Part 2: Electronic components*

ISO 8258:1991, *Shewhart control charts*

MIL STD 750, 2052 *Test methods for semiconductor devices, 2000 series test methods*

MIL STD 883, 2020 *Test methods for microelectronics, 2000 series test methods*

3 Definitions

For the purpose of this part of IEC 60300 the following definitions, as well as those given in IEC 60050(191), apply.

NOTE – Terms of particular importance for reliability stress screening of repairable items are quoted with the IEC 60050(191) reference number stated in square brackets. The quotation includes all notes, whether they are relevant to this standard or not. Additional comments to an IEV term, relevant to RSS, are stated as "remark".

3.1

reliability improvement

a process undertaken with the deliberate intention of improving the reliability performance by eliminating causes of systematic failures and/or by reducing the probability of occurrence of other failures [IEV 191-17-05]

Remark – Reliability stress screening reduces the probability of occurrence of other failures. The systematic failures are principally catered for by a reliability growth programme, but some may appear during the RSS process.

3.2

systematic failure

a failure related in a deterministic way to a certain cause, which can only be eliminated by a modification of the design or of the manufacturing process, operational procedures, documentation or other relevant factors

NOTE 1 – Corrective maintenance without modification will usually not eliminate the failure cause.

NOTE 2 – A systematic failure can be induced at will by simulating the failure cause. [IEV 191-04-19]

NOTE 3 – Design, in this case, includes hardware and/or software as appropriate.

3.3

reliability screening (process)

a process of detection of flaws and removal and repair of weak items for the purpose of reaching as rapidly as possible the reliability level expected during the useful life

NOTE 1 – IEV 191-17-02 definies the term "burn-in". This term, however, is used by many manufacturers to describe a so-called "soak test", which is only one of many possible ways of screening. Furthermore, "burn-in" may include ageing, the purpose of which is to stabilize parameters, and where in many cases no failures occur.

NOTE 2 – IEV 191-14-09 defines the term "screening test". This term, however, is defined too broadly to be applicable in the present context because it encompasses screening for all types of non-conformities. Furthermore, reliability screening is a process, not a test.

NOTE 3 – Environmental test levels, e.g. IEC 60068-2, are often used in the stress screening process in order to use standard test equipment and standard control programmes for the equipment.

3.4

useful life

under given conditions, the time interval beginning at a given instant of time, and ending when the failure intensity becomes unacceptable or when the item is considered unrepairable as a result of a fault

NOTE – In French the term "durée de vie utile" is the duration of this time interval.
[IEV 191-10-06]

3.5

reliability stress screening (process)

a process using environmental and/or operational stress as a means of detecting flaws by precipitating them as detectable failures

NOTE – The RSS process is designed with the intention of precipitating flaws as detectable failures. An ageing process designed solely with the intention of stabilizing parameters is not a RSS process and therefore outside the scope of this standard.

3.6
item

any part, component, device, subsystem, functional unit, equipment or system that can be individually considered

NOTE 1 – An item may consist of hardware, software or both, and may also in particular cases include people.

NOTE 2 – In French the term "entité" is preferred to the term "dispositif" due to its more general meaning. The term "dispositif" is also the common equivalent for the English term "device".

NOTE 3 – In French the term "individu" is used mainly in statistics.

NOTE 4 – A number of items, e.g. a population of items or a sample, may itself be considered an "item".

[IEV 191-01-01]

NOTE – In the context of a reliability screening process, only the hardware part of an item is relevant. Current examples are electronic components, assemblies, equipment and hardware parts of systems.

3.7
weak item

an item which has a high probability of failure in the early failure period due to a flaw (see also 3.15, early failure period)

3.8
component

a single item which is not intended to be repaired

3.9
weakness

any imperfection (known or unknown) in an item, capable of causing one or more weakness failures.

NOTE – Each type of weakness is assumed to be statistically independent of all other such types.

3.10
weakness failure

a failure due to weakness in the item itself when subjected to stress within the stated capabilities of the item

NOTE – A weakness may be either inherent or induced.

[IEV 191-04-06]

3.11
flaw

a weakness in an item, which gives rise to early weakness failures

NOTE 1 – A flaw is localized in a component or caused by interaction between components with characteristics close to the margins of the design requirements.

NOTE 2 – An interaction between components can for example be caused by tolerances in the parameters of the components (e.g. resistance, capacitance or time delay). This interaction will have to be corrected by a design change. The RSS process will however be able to screen away the items where the combinations of the tolerance values cause failures. Interconnections, such as connectors and sockets, are defined as components. Solderings are considered a part of the component when it is mounted in an assembly.

3.12
inherent flaw

a flaw in an item related to its technology and manufacturing process

3.13
induced flaw
a flaw in an item related to assembling, testing, handling or other manipulations of the item after it has been manufactured

NOTE – The induction may for example take place at the component manufacturer's plant, during transportation or at the system manufacturer's plant.

3.14
flaw density
the average number of flaws in a population of items (component, assembly, subsystem or system), under consideration

3.15
early failure period
that early period, if any, in the life of an item, beginning at a given instant of time and during which the instantaneous failure intensity for a repaired item or the instantaneous failure rate for a non-repaired item is considerably higher than that of the subsequent period
[IEV 191-10-07]

NOTE – The early failure period is the period when the weak items fail.

3.16
screening strength
a measure of the capability of a screening process designed with specified parameters, to precipitate flaws into failures

NOTE – The screening strength is a function of the type of screening as well as the screening parameters.

3.17
screening relevant failure
a failure brought about by the screening process as a result of one or more flaws

4 Acronyms

4.1 ATE: automatic test equipment

4.2 BITE: built-in test equipment

4.3 ESD: electrostatic discharge

4.4 HASS: highly accelerated stress screen

4.5 MOSS: multi-operational stress screening

4.6 PCB: printed circuit board

4.7 PIND: particle impact noise detection

4.8 PWA: printed wiring assembly

4.9 RSS: reliability stress screening

4.10 SMT: surface mount technology

5 General considerations for a reliability stress screening programme

An RSS programme should not be required in a contract unless it is a necessity to achieve the required reliability level concerning early failures. One or more of the analyses described in clause 7 combined with a specified maximum level of early failures should be stated instead.

If a conflict should arise between this International Standard and the relevant contract or specification(s), the latter should apply.

Since this standard requires the stress screening programme to be tailored to a specific item, several issues have to be agreed upon between the customer, the manufacturer, and an independent reliability screening laboratory (if any). All contracts or RSS plans should refer to this International Standard and any other International Standard on the subject of the RSS to be employed.

In addition, the party given the discretion and the areas in which discretion is to be exercised should specifically be mentioned in the contract or RSS plan in the following cases:

- when selecting, modifying or deleting a specific RSS process;
- when optimizing the duration of the stress screening process;
- when changing the screening process to a sample;
- when accepting or rejecting a lot on the basis of the screening process.

Furthermore, the following recommendations apply:

- where specific reliability stress screening processes or special control and optimization procedures have to be agreed to, the agreements should be stated in an annex to the contract or RSS plan;
- where any matter requiring agreement has not been resolved, it should be specifically identified in the contract or RSS plan, and suitable provisions, including deadlines for agreement and dispute resolution procedures, should be stated.

In all instances, the applicable contract or subcontract should identify the party responsible for performing the RSS, the party liable for the consequences of failing to perform the RSS appropriately or the consequences of the system failing to comply with the specifications, the scope or limitations of such liability, and the nature of, or limitations on, remedies available to the damaged party.

6 General information about the reliability stress screening process

As a result of the reliability growth process, hardware will normally mature to its predicted, or inherent, design reliability level by the end of the development cycle. However, this inherent reliability level is very difficult to maintain because it is often degraded by the introduction of different manufacturing processes. A well designed stress screening programme will help to preserve this inherent reliability level.

Forcing flaws to manifest themselves as failures in the factory rather than in the field will increase productivity, reduce warranty cost, and improve customer satisfaction. This will enhance the manufacturer's reputation in the eyes of the user and improve the overall life cycle cost of the product.

The data generated by the screening process may also be used to improve the product. RSS failure information can highlignt workmanship problems or identify unqualified parts/material suppliers. By addressing these deficiencies, product quality will be enhanced and screening process costs may be reduced and/or the screening process eliminated.

The RSS process should always be regarded as a temporary measure that allows the manufacturer to deliver items with an acceptable quality to the customer, while at the same time solving the problems in design, raw materials, components and processes that cause early failures in the finished item. The aim should always be to eliminate the RSS process or reduce it to a sample of the finished items.

When performing an RSS process on a sample of the items, it can be regarded as a screening process of production lots, since the purpose of the RSS process on a sample is to identify production lots with too high a percentage of early failures. The RSS process may then be reintroduced on a 100 % basis to the identified lots and to the following lots in the production. In case the production is not divided into lots, a fictive lot may be identified, as for example a week or a day's production. For an RSS process of single items, each individual item should be considered separately.

7 Analysis of the benefits of the reliability stress screening process

As with any other manufacturing process, the reliability stress screening process costs money, and is considered a separate activity, with time and milestones allocated in the schedule.

Accordingly, at least one of the following analyses should be performed to ensure cost effectiveness before a decision is made to implement an RSS programme:

a) an analysis which indicates that the reliability contract requirements will not be achieved unless a stress screening programme is implemented;

b) a cost-benefit analysis which clearly indicates the advantage of the stress screening process over any other alternative;

c) a field data analysis, when available, that reveals an unacceptable level of early failures causing high warranty cost and/or customer dissatisfaction.

8 Characteristics of a successful reliability stress screening programme

Once it has been determined that an RSS screening process is appropriate (see clause 7), the following elements should be addressed to ensure that an effective RSS programme is implemented:

a) the screening process should be tailored, based on the type of hardware and the applicable manufacturing processes. Accordingly, a thorough knowledge of the materials/parts involved, their properties, failure mechanisms and manufacturing processes is essential;

b) quantitative goals should be set for the screening process;

c) the screening programme should be dynamic. This means that the process should be continuously monitored and changes made, if necessary, based on the analysis of the data resulting from the screening process. Without such dynamism, the screening process may not be cost effective, and the screening process goals may not be achieved;

d) the screening process should neither degrade in a significant way nor destroy hardware without flaws. This is avoided by designing the screens such that their stress level does not exceed the maximum specification limits of the hardware under consideration. The screening process should not consume an unacceptable portion of the useful life of the hardware. When screening lots based on a sample, destructive tests such as, for example, HASS, can be used;

e) the screening process should not introduce failure modes which cannot happen during normal field operation;

f) the selected application level of the screening process (component, assembly, subsystem or system) should be based on sound technical and cost trade-off analysis, in order to optimize the screening process. In other words, it should be selected to precipitate as many flaws as possible in the shortest time and at the lowest cost;

g) the personnel associated with the screening programme, including management, should be educated to understand the process, its purpose and how to achieve the screening process goals.

9 Screening types

Screening can be classified according to the following:

a) where it is carried out, i.e. component manufacturer, system manufacturer, screening laboratory, end user (see figure 1);

b) the items screened, i.e. component screening, subsystems screening of PWAs or systems (see figure 1);

c) whether the item is repaired or not (see IEC 61163-1 and IEC 61163-2);

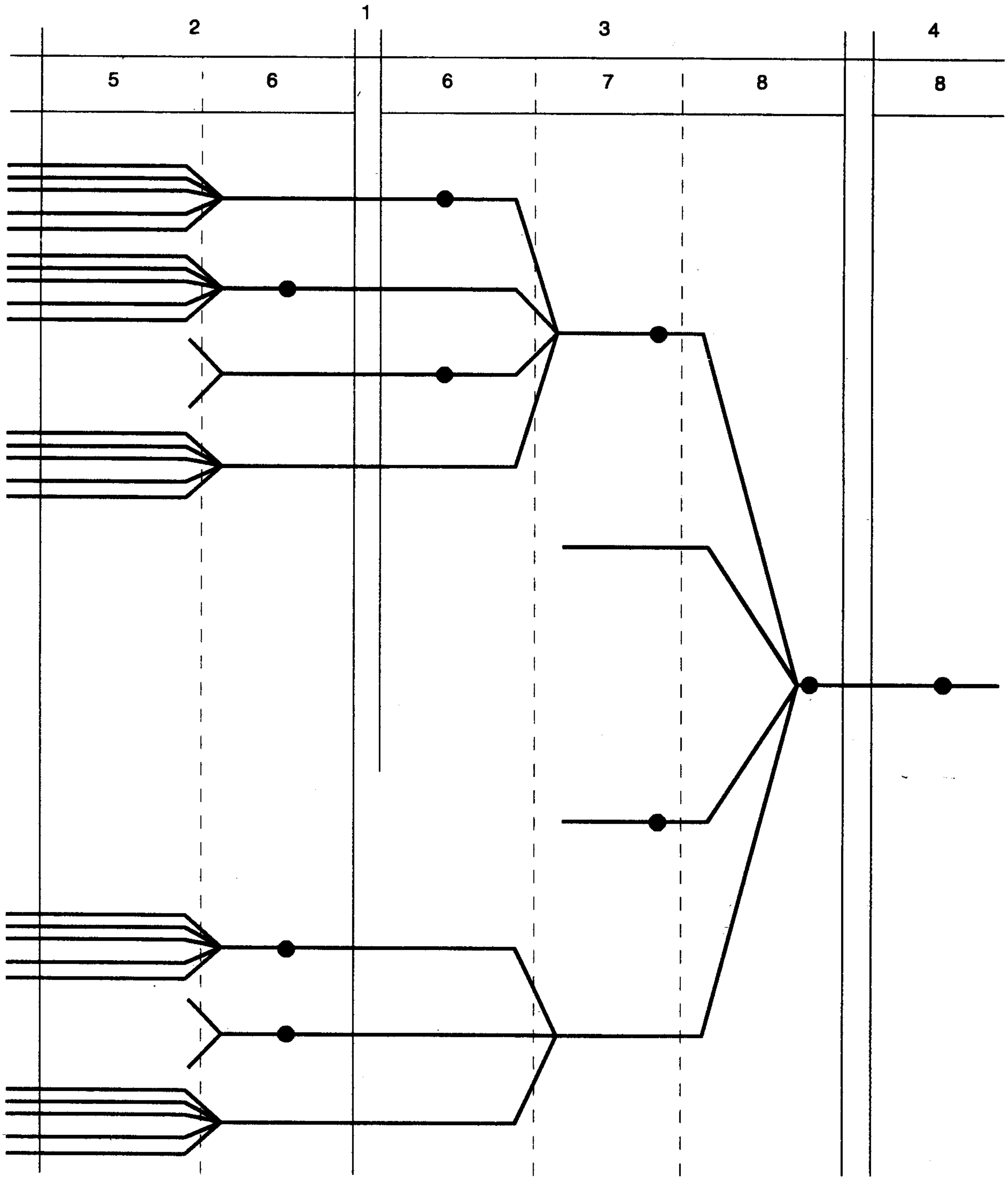
d) whether the items are produced in lots or as single items (see IEC 61163-1 and IEC 61163-2);

e) whether increased stress is used, i.e. RSS (see introduction);

f) the type of stress used, i.e. constant temperature, temperature change, vibration, shock, bump, operational load, electric transients, etc. (see 15.3);

g) the population being screened, i.e. 100 % screening, lot screening, and screening of a sample of the production (see clause 6);

h) the duration of the RSS process, i.e. fixed time, variable time and failure-free period (see IEC 61163-1 and IEC 61163-2).



1 Screening laboratory
2 Component manufacturer
3 System manufacturer
4 End user

5 Material level
6 Component level
7 Subsystem level
8 System level

Horizontal lines symbolize materials, components, subsystems and systems. Bullets indicate levels where RSS can be performed.

Figure 1 – Levels where reliability stress screening can be performed

10 Screening levels

A stress screening process can be applied to electronic hardware at the component, assembly, subsystem or system level. Although an effective component screening process programme can eliminate most of the flaws inherent to the components, it cannot replace an assembly screening process. Certain types of flaws, such as drifts and propagation delay problems can only be detected at the assembly level. In addition, manufacturing processes and workmanship problems, such as dry solder joints, poor connections, board discrepancies and broken wires, can only be detected by an assembly level screening process. Even good components which survive a component screening process may exhibit flaws during an assembly level screening process. This may be a result of degradation during the manufacturing cycle due, for example, to electrostatic discharge (ESD), soldering, testing or rough handling.

When selecting the application level of a screening process, it is important to consider that it is more difficult and more costly to troubleshoot and repair failures at higher levels of assembly, such as the system level.

When using screening at the component, assembly or subsystem level with operational stress, it is necessary to consider the additional cost of facilities, equipment and fixtures required for the screening process.

When using screening at the system level, it is possible to use, for monitoring and/or detection/localization of failures, the existing built-in test equipment (BITE) or automatic test equipment (ATE), if any.

It is also important to note that the stresses applied during an assembly level screening process should be low enough to avoid overstressing the weakest components in the assembly. This may not result in an adequate screening process for other components that may require higher stresses to precipitate flaws into failures. A component level screening process can be used to address this problem.

If a few components limit the stress level this indicates that they are the weakest part of the assembly. To avoid overdesign and underdesign in the item, the design should be made so that all components are as far as possible equally robust.

If some components cannot be equal in strength to the others in the design, they can be mounted after the RSS process or be specially protected during the reliability stress screening process (i.e. cooling, supporting, cushioning, etc.).

Since RSS is a temporary measure used only until the design, the components and the manufacturing processes are "debugged", the product should be designed so that permanent RSS is not necessary.

In summary, when selecting a screening process level, one should consider the following factors:

- the types of flaws to be precipitated;
- the most effective application level of a screening process, from the technical and financial point of view;
- the quality of incoming materials/components, (where these have been previously screened by their manufacturers).

11 Screening strength

The efficiency of the RSS process can be expressed in numbers as the screening strength. This is defined as the fraction of flaws that the RSS process precipitates as failures. The screening strength depends on the following elements:

- the duration of the RSS process (with longer durations of time, the effect levels off);
- the stress types;
- the stress levels;
- the efficiency of the test after the RSS process (test coverage);
- the efficiency of the monitoring during the RSS process (if any);
- the decision rules (i.e. fixed RSS-time or required failure-free period (see IEC 61163-1).

In IEC 61163-1 and IEC 61163-2 fixed stress types/cycles and levels are usually used combined with a varying length of the failure free period. The duration of the failure free period is varied so that the maximum expected number of flaws after the RSS-process (i.e. on the market) is kept below a specified level.

12 Selection of screens

Before selecting a screen type it is important to understand the different failure mechanisms associated with the hardware under consideration. Such understanding requires a thorough knowledge of the properties and behaviour of the materials employed in the electronic hardware, as well as the different manufacturing processes which the hardware will experience and which may induce flaws into the hardware.

The screen selection should be independent from the applicable field environments but precipitate the same failure modes. However, the types of screens selected should neither degrade in a significant way nor destroy the hardware being screened. Care should be taken not to induce flaws in the items during handling (i.e. electrostatic discharge damage (ESD damage)).

13 Flaws detected by a reliability stress screening process

Generally, the RSS process will aim at detecting the following three types of flaws:

a) Inherent flaws

These types of flaws are component- or materials-related. They are due to inadequate design or poor manufacturing process of components. Parameter drifts, incorrect tolerances, poor bonding and contamination are examples of inherent flaws in components/materials.

b) Induced flaws

These types of flaws are found in the assembly level screening process and they are due to poor manufacturing processes, poor handling of components/materials during assembly, poor workmanship or inadequate quality control procedures.

c) Inadequate design

RSS is mainly intended to detect inherent flaws or induced flaws. Inadequate design should preferably be addressed by other tests, such as well structured design acceptance tests. Flaws caused by inadequate design can be found in both components and assemblies. These are types of design flaws that cannot be detected by common means such as worst case analysis, design acceptance tests, reliability tests or any other qualification tests, but will only precipitate as failures when exposed to one or more types of stresses. Tolerance interference, drifts and propagation delay problems are examples of flaws due to inadequate design.

14 Pre-production screening process

A pre-production screening process test (see 15.5) can be very useful for practical evaluation of the types of flaws and their associated densities, and in assessing the effectiveness of the different types of screens applicable when precipitating these flaws. The analyzed data of a pre-production screening process can be very valuable for the fine-tuning and stabilization of the production screening process. However, one should try to avoid misinterpretation of such data, as it may be deceiving in many cases such as those indicated below:

- pre-production hardware configuration may be different from production configuration;
- the quality of components/materials used in pre-production hardware may be different from that of production hardware;
- lack of adequate quality control during pre-production phase;
- immature manufacturing processes during pre-production phase.

These factors have to be considered when using pre-production screening process data to select the production screening process and deciding on its parameters.

15 Planning, performing and eliminating a reliability stress screening process

15.1 General

When the outcome of the analysis described in clause 7 has indicated the need for an RSS process, then a screening plan is called for. Due to the numerous types of electronic hardware, and all their possible different applications, the specific details of the planning process, such as screening process application level, types of screening process and stress levels, cannot be standardized. However, the following outlines a general planning procedure, with some guidance on how to select the specific parameters.

15.2 Step 1 – Identification of objectives and goals

This step is essential in the planning process. Effectiveness of the screening process cannot be ensured without clear identification of objectives and goals to be achieved.

15.2.1 Identification of objectives

An RSS process is normally applied with at least one of the following objectives in mind:

a) achieve a certain required reliability level. This would be the case when reliability predictions, field data or test data, indicate a lower level of reliability than required or expected;

NOTE – It is important to note that this lower reliability level will be due to flaws and not to other types of failures that cannot be eliminated by RSS or are better eliminated by other means.

b) achieve a specified maximum allowable flaw density level or better on the market. This would be the case when a contract specifies a maximum flaw density level, or when a field warranty data and cost trade-off analysis have indicated the need to reduce the flaw density to a certain level, in order to meet customer expectations and/or achieve cost objectives;

c) precipitate the maximum number of flaws for a known allocated budget. This would be the case when a reliability stress screening process programme is called for, but there is a fixed cost budget allocated to it.

15.2.2 Identification of goals

To ensure the effectiveness of the screening programme, the results of the screening process should be measurable against pre-set goals. This necessitates that these pre-set goals be quantitative. The adequacy of the screening level, the testing regime and the expected or observed number of failures should be considered. When setting a goal for flaw density the following factors should be considered:

a) complexity of the hardware under consideration: complexity is assessed by the number and variety of components/subcomponents and materials used in the hardware under consideration, as well as by the number and variety of connections/interconnections used to build it. The higher the complexity, the higher the flaw density which can be expected;

b) technology: a well established technology will have less probability of containing flaws than a technology which has not yet matured;

c) manufacturing processes: new or complicated manufacturing processes, as well as poor or inadequate quality control processes, will contribute to a high flaw density. While, on the other hand, a mature and adequately controlled manufacturing process will reduce the likelihood of inducing flaws into the electronic hardware;

d) previous screening process: whether or not the purchased materials, components or modules have survived a previous vendor or subcontractor screening process will influence the flaw density of the hardware;

e) application environments: it is important to evaluate the type and level of stress to which the hardware will be exposed during field applications. Certain types of flaws which become failures in a stressful application environment may very well survive the hardware useful life in a not so stressful application environment. However, such evaluation necessitates a thorough knowledge of the characteristics as well as the stress and time dependency factors of the types of flaws being considered.

NOTE – It is very important to emphasize that the environmental and operational profiles have absolutely no relation to the types of screens selected. This is due to the distinct difference between environmental qualification tests and the RSS process. Depending on the type and maturity of the manufacturing processes employed to produce the hardware, the flaws will vary in both intensity and density. Flaws of high intensity come close to causing failures due to their degradation mechanism. These high intensity flaws will cause failures during the hardware useful life, while on the other hand, flaws of low intensity may require harsh environments to cause failures, and may not fail at all in benign environments.

Considering all of the above factors in comparison with similar hardware, with similar complexity and manufacturing processes, a maximum flaw density can be established, for example measured as the maximum allowable percentage of weak items on the market (see IEC 61163-1).

15.3 Step 2 – Screening process design and application

Selection of screen types, their parameters, their strength and the appropriate level of their application is the most important step in the entire process. An ideal screen is one that forces flaws into factory failures without destroying or degrading the good components/materials.

A thorough understanding of the topics listed below is essential for proper screen design and application. Some screening sequences can be found in IECQ documents, for example, the IEC 60747 and IEC 60748 series.

a) Screening process types

The different types of screening processes, their characteristics and their capabilities in accelerating the degradation mechanisms.

The following are examples of different types of electrical, mechanical and other screening processes which constitute potential candidates for the stress screening process:

- elevated temperatures;
- low temperatures;
- temperature shock;
- temperature cycling (ramp rate);
- random vibration;
- sine vibration;
- constant acceleration;
- bump and shock;
- electrical stress, including transients and other electromagnetic disturbances;
- humidity;
- altitude;
- combined elevated temperature and vibration;
- combined temperature cycling and random vibration;
- combined temperature cycling, random vibration and power cycling;
- combined temperature cycling, random vibration and altitude;
- combined temperature cycling and sine vibration;
- intermittent functional operation;
- operational loading;
- power cycling.

b) Common screening processes

Examples of commonly used screening processes (and their characteristics) include the following.

1) Elevated temperature: an effective screening process which can be applied at any level. The component with the lowest temperature rating will determine the maximum temperature that can be used. Therefore, a higher temperature value can be tolerated for components and for lower assembly levels. When compared to other screens it is considered the least expensive.

Stress parameters:

- temperature value;
- duration of exposure.

Typical flaws detected: drifts, poor connections, contamination and chemical problems.

NOTE – When controlling the elevated temperature stress screening process, it is important to monitor the temperature at or near the component, and not the average temperature of the oven. The temperature monitoring system should be independent of the temperature control system.

2) Temperature cycling: a very effective screening process that can be applied at all levels. Its effectiveness is due to its high potential capability to reveal a wide variety of inherent, process induced and workmanship induced flaws.

Stress parameters:

- high and low temperature values;
- rate of change;
- number of cycles;
- dwell time.

Typical flaws detected: incorrect tolerances, drifts, hermetic seal failures, poor connections, bad relay contacts, contamination, chemical problems, and PCB flaws.

NOTE – When controlling the temperature cycling stress screening process, it is important to monitor the temperature at or near the component, and not the average temperature of the oven. The temperature monitoring system should be independent of the temperature control system. The rate of temperature change is strongly influenced by the thermal mass in the test chamber (items being screened, connectors, cables, control equipment, etc.). If the items being screened are turned off when the cooling cycle starts, and on when the heating cycle starts, the maximum thermal stress can be expected just after the items are turned on.

3) Vibration: an effective screening process, especially when applied at higher assembly levels. Vibration is for example a useful screening process for some electromechanical parts.

Stress parameters:

- type of vibration (sine or random);
- vibration level, frequency and amplitude;
- number of axes (of possible six degrees of freedom);
- duration of exposure.

Typical flaws detected: loose hardware, poor connections, broken wires, structural problems and particle contamination. A special vibration screening process is the Particle Impact Noise Detection (PIND). (See MIL STD 750, 2052 and MIL STD 883, 2020.)

NOTE – The resonances may cause part of the item being screened to experience up to approximately 25 times the acceleration level imposed on the item itself. The monitoring circuit should be independent of the control circuit for the vibration equipment. Vibration can be applied along one, two or three axes or in an oblique vector applying vibration along all three at the same time. When choosing the direction(s) of vibration the resonance frequencies for the subsystems and components as well as their robustness should be considered. A sinusoidal vibration with a fixed frequency will excite primarily components and subsystems with a resonance frequency nearing this frequency. If a sinusoidal sweep is used it will excite one resonance frequency at a time. A random vibration will excite all resonances at the same time, increasing the stress level and the probability of collision between components.

4) Temperature cycling and vibration: a very effective screening process, especially when applied at the higher assembly levels, since it has a high capability for revealing both component and manufacturing process flaws.

Stress parameters: in addition to the stress parameters for temperature cycling and vibration, the only other parameter is the choice of combined or sequential screen application.

Typical flaws detected: poor solder joints, contamination, loose hardware, intermittent and poor connections.

NOTE – When controlling the temperature cycling stress screening process it is important to monitor the temperature at or near the component, and not the average temperature of the oven. The temperature monitoring system should be independent of the temperature control system. The rate of temperature change is strongly influenced by the thermal mass in the test chamber (items being screened, connectors, cables, control equipment etc.). If the items being screened are turned off when the cooling cycle starts, and on when the heating cycle starts the maximum thermal stress can be expected just after the items are turned on. The resonances may cause part of the item being screened to experience up to approximately 25 times the vibration acceleration level imposed on the item itself.

The monitoring circuit should be independent of the control circuit for the vibration equipment. Vibration can be applied along one, two or three axes or in an oblique vector applying vibration along all three axes at the same time. When choosing the direction(s) of vibration the resonance frequencies for the subsystems and components as well as their robustness should be considered. A sinusoidal vibration with a fixed frequency will excite primarily components and subsystems with a resonance frequency nearing this frequency. If a sinusoidal sweep is used it will excite one resonance frequency at a time. A random vibration will excite all resonances at the same time, increasing the stress level and the probability of collision between components.

5) Bumps and shock: a screening process which can be used for the same purpose as random vibration. A bump or a shock will for example excite the resonance frequencies of each component in the item. The resultant vibration mode is often similar to that observed with a random vibration input. Note, however, that vibration moves the item between the extreme amplitudes while bump and shock ends with a zero amplitude. A bump or shock will therefore tend to move components in the item in one direction, while vibration will tend to move them back to the point of origin.

NOTE – The resonances may cause part of the item being screened to experience up to approximately twice the shock or bump acceleration level imposed on the item itself. Shock or bump can be applied along one, two or three axes or in an oblique vector applying shock/bump along all three axes at the same time. When choosing the direction(s) the resonance frequencies for the subsystems and components as well as their robustness should be considered. Items that are too large for a shock or bump equipment can be excited for example by a pneumatic hammer on the chassis.

6) Constant acceleration: a screening process which is often used for weak mechanical assembling processes of parts in components.

7) Humidity: humidity is seldom used in screening processes, but is often used as a destructive test on a sample in order to screen lots, as is the case with the Highly Accelerated Stress Screen (HASS) (see also levels in IEC 60749).

8) Operational load: operational load can be used for RSS either alone or combined with other stress types. The operational load experienced on the market is usually increased, for example by using maximum input load, maximum output load, a rapid load cycle, maximum or minimum voltage, minimum cooling, etc.

NOTE – This type of stress screening can usually be established very cheaply using the item itself and its control circuits to control, monitor and detect failures during the screening process.

9) Multi-operational stress screening (MOSS): in this RSS process several stress types are used in the same RSS process. The advantage of such a screening process is that it precipitates the flaws that would also occur due to stress interactions that will be experienced by the product during use. Ideally MOSS would be the preferred option for all screening, but often this is not possible due to practical constraints, time and cost considerations.

c) Failure Mechanisms

An ideal screening process is one that is designed with specific types of flaws in mind. This requires sound understanding of the different types of failure mechanisms, which necessitates thorough knowledge of the following subjects:

- degradation mechanisms which can cause failures under operational and/or environmental stresses, as a result of specific flaws;
- the different types of materials employed in electronic hardware, especially in microelectronic devices. Examples of such materials are semiconductors, ceramics, insulators, polymers, chemical compounds, plastics and different types of alloys and metals;
- behaviour and performance characteristics of these materials when exposed to a wide variety of operational and environmental stresses, and the corresponding threshold levels;
- the different types of interfaces, which are found in microelectronic devices, electronic circuitry and higher electronic assemblies, such as metal-to-metal, metal-to-semiconductor and dielectric-to-semiconductor. It is important to understand the main characteristics of these interfaces, such as thermal expansion, chemical properties, crystal structures and many others.

d) Manufacturing processes

Knowledge of the manufacturing processes to which the hardware will be exposed is important in the design of the screening process. There are numerous types of manufacturing processes which are involved in producing materials, microelectronic devices and electronic assemblies. Depending on the application level of the screening process and the type of the hardware under consideration, the applicable manufacturing processes, which have the potential of inducing flaws into the hardware, should be considered.

For example, the manufacturing processes involved in producing microelectronic devices may induce flaws such as: trapped moisture/gases, residual chemicals, cracks in hermetic sealing, poor bonds, solder fluxes, contaminations, improper die attachment and others. Another example is the manufacturing processes used to build PCBs, of which the most common process is soldering. The soldering process can induce a variety of flaws due to unsuitable temperature and/or duration of solder flow, improper solder techniques, improper choice of flux, improper placement or movement of components prior to solder solidification, improper choice of cleaning solvents and others.

As a result of technological advancement, and the emphasis on automation, new or modified processes have been introduced into the manufacturing cycle. Until these processes are fully matured, they are considered to be of high potential to induce flaws. For example, with the introduction of SMT, new types of flaws due to the soldering process were introduced; however, it will take some time before data are collected and analyzed to fully understand the SMT soldering process, associated flaws and their failure mechanisms.

e) Operating and non-operating specification limits

As previously stated, the purpose of an RSS process is to precipitate flaws without destroying or degrading the hardware under stress. It is important when designing the screening processes and selecting their parameters that specification limits of the hardware under stress should not be exceeded. Overstressing beyond the specification limits should be avoided, except when screening lots based on a sample.

f) Adequacy of the functional test in detecting failures caused by flaws

It is strongly recommended to test the items screened before and after the reliability stress screening process with the same test equipment and test programme. This will increase confidence in the estimate made of the number of failures occurring during the RSS process (see figure 2).

In order to detect intermittent failures and obtain a precise time for each failure, it is recommended to monitor some of the functional parameters of the items during the RSS process (see figure 2).

When designing screening processes for targeted flaws, the availability of test equipment, and its capability of detecting the different failure modes caused by these flaws, should be considered. For example, failures can happen in an intermittent mode, which requires the duration of the functional tests (while stress is being applied) to be sufficiently long. Another example is when failures occur only in a dynamic mode, (input/output signals are exercised), such as failures caused by drifts and propagation delay problems. Again, the ability to exercise and monitor such modes should be evaluated.

g) Screening process objectives and goals

The screening process design should be tailored according to the screening programme objectives and goals. For example, the expected flaw density prior to the screening process and the targeted flaw density after the screening process should be agreed upon.

h) Cost of alternative screens and application levels

When designing screening processes, the cost of the screening process equipment, (test chambers, vibration tables, etc.), functional test instruments and labour cost, should be evaluated against the effectiveness of the screening process type and application levels in precipitating flaws. These cost analyses are explained in more detail in 15.4. Due to economic considerations and in order to use standard stress equipment i.e. climatic chambers and vibration equipment, the stress severities from the IEC 60068-2 series should be selected whenever possible.

15.4 Step 3 – Cost-benefit analysis

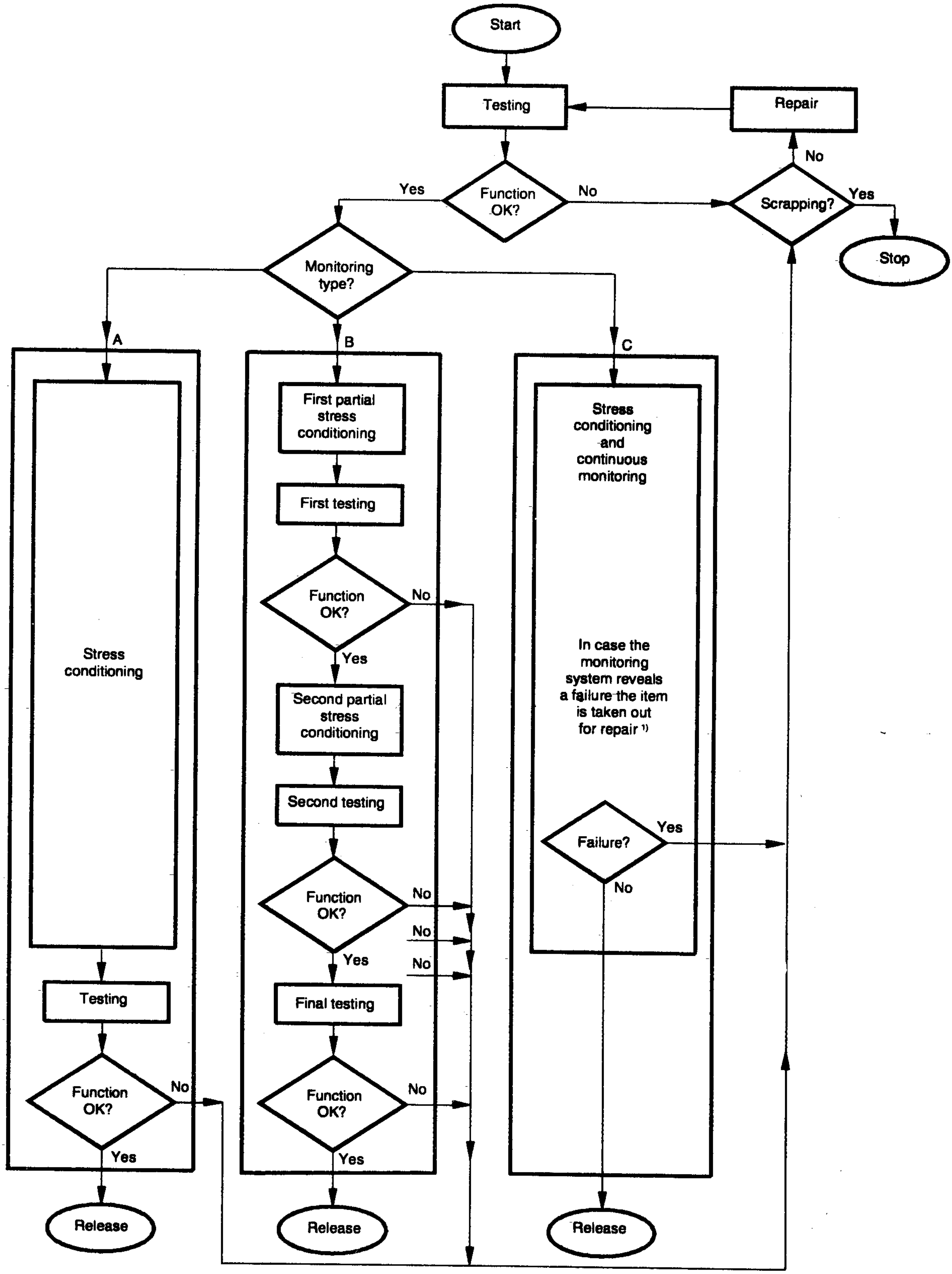
15.4.1 General

Whether the objective is to meet specified reliability requirement, or to reduce warranty cost, the RSS process is mainly a cost-driven process. Accordingly, cost-benefit analysis should be performed to assess the screening process. Basically, in order to benefit from the screening process, the total cost of the screening process should be less than the total cost of troubleshooting/repair of factory and field failures, warranty and bad reputation for the company.

15.4.2 Factors to be considered in evaluating the screening process cost

The following factors should be considered in evaluating the screening process cost:

- application level (component, assembly, subsystem or system);
- amount of hardware to be screened (number per week and volume);



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[1] Sometimes it may not be practical to remove and repair the failed item before the end of the period T_M.

Figure 2 – Reliability stress screening of repairable items

- cost of facilities, equipment, fixtures, etc., required for the screening process;
- cost of functional test equipment required for failure detection, if applicable;
- duration of the screening process;
- inventory cost for hardware being screened;
- documentation cost;
- labour cost: screening process planning, conducting and monitoring of screening process, collection and analysis of screening process data, report preparation, administration and logistics;
- rework and scrap costs;
- cost of personnel training.

15.4.3 Factors to be considered when evaluating cost saving due to screening process

The following factors should be considered in evaluating the cost saving due to the screening process:

- increased reliability and availability of the items being screened (translated into monetary value, when applicable);
- reduction of factory troubleshooting and repair costs/time (if any);
- reduction of field troubleshooting and repair costs;
- reduction of test equipment and tools required for factory/field troubleshooting and repairs;
- reduction of equipment, tools and spares required for retrofits due to reduction of factory/field failures;
- reduction in administrative and logistics costs associated with factory/field failures;
- increased customer satisfaction, company goodwill and reputation (translated into monetary value, if possible).

15.5 Step 4 – Preparation of a screening plan

The screening plan should include at least the following elements:

- the RSS standard chosen for the RSS process (i.e. IEC 61163-1 or IEC 61163-2);
- screening programme organizational structure, identifying personnel and their responsibilities;
- identification of the main applicable failure modes and mechanisms;
- stress screening programme objectives and quantitative goals;
- identification of the hardware to be screened;
- identification of applicable screening process levels;
- identification of all the different types of screening processes selected;
- description of the rationale behind the selections and the important parameters for each of the selected screening processes;
- description of the intended data collection, analysis and corrective actions procedures for screening process optimization;
- assumptions of the expected pattern of failures (statistical distributions) and approximations made for easier analysis;

- criteria for termination (or change in sample size) of the RSS process;
- monitor equipment (real time);
- test chambers;
- availability of test support equipment and personnel;
- criteria for completing units under test that fail during the RSS cycle;
- criteria for rerunning RSS if the unit that failed during the RSS process requires extensive repair or replacement of major assemblies.

15.6 Step 5 – Screening process data collection, analysis and corrective actions

15.6.1 General

One of the most important characteristics of a successful screening programme is the dynamism of the screening process. For screening process optimization, continuous data collection and analysis, followed by the necessary corrective actions, are required (see figure 3).

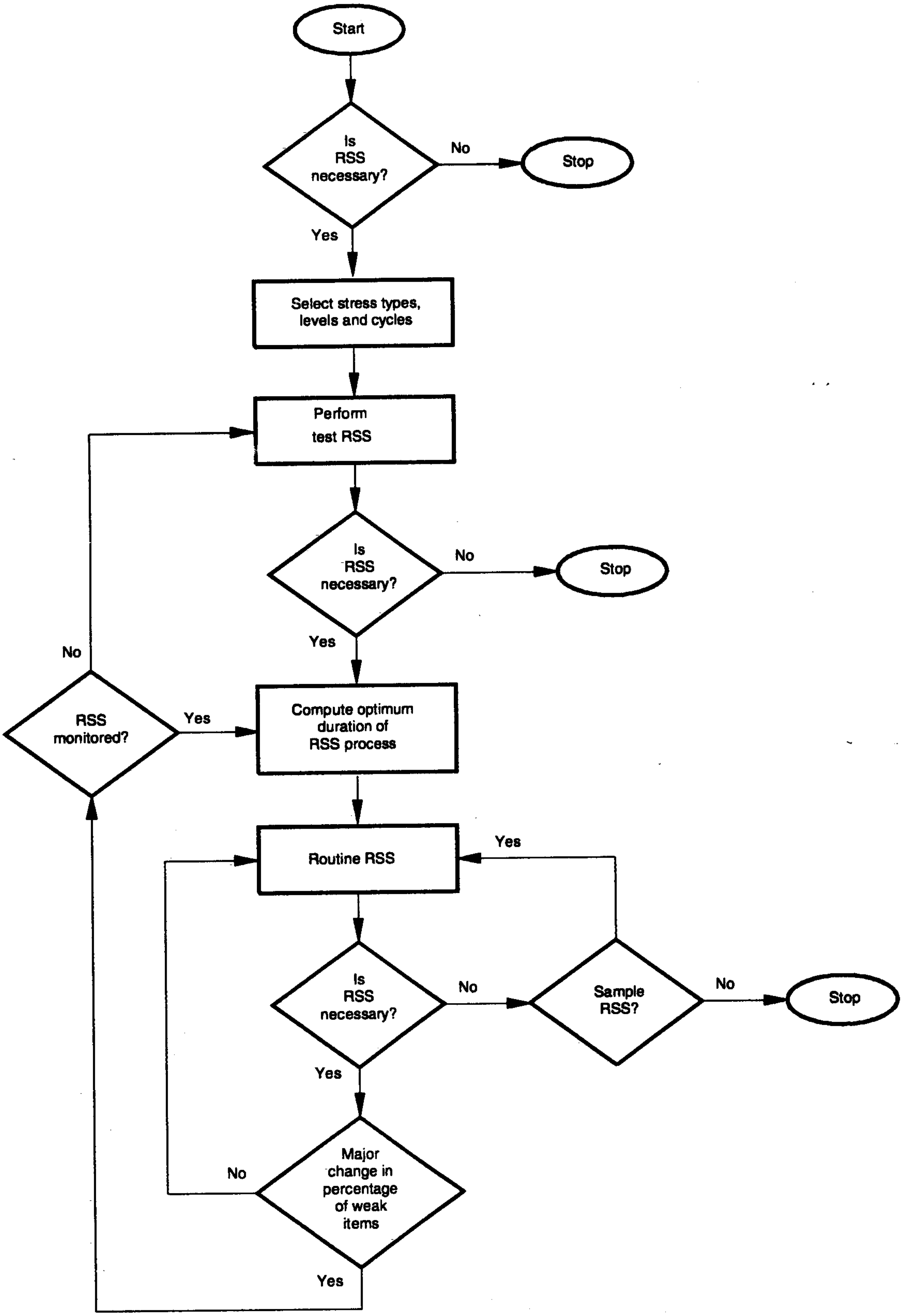


Figure 3 – Flow chart for control of a reliability stress screening process

IEC 61163-1 and IEC 61163-2 use a constant stress level (the highest acceptable level for the item being screened). The duration of the stress screening process is continuously optimized so that it is increased when a high defect density is observed and shortened when a low defect density is observed. The aim is to keep the defect density after the stress screening process (on the market) below the specified limit.

Since the effect of the screening process usually decreases with the increased duration of the process in time or cycles, the required duration of the screening process is determined through a test. During this test a sample of the items to be screened is subjected to the chosen screening stress process (level) for a period of time that is long enough to precipitate all expected relevant flaws as failures. The failures observed are analyzed in order to estimate the flaw density in the items produced and the time required to precipitate the required percentage of flaws as failures.

The estimated flaw density is compared with the maximum acceptable level on the market. If the level observed in the test is higher than the maximum acceptable level on the market, RSS is required.

The required duration of the RSS process can then be determined using IEC 61163-1 and IEC 61163-2, and routine RSS of the production start.

The failures occurring during the stress screening process are monitored continuously. If the failure level increases significantly (a P-control chart can be used, see ISO 8258), a process has probably got out of control or a bad batch of components/raw materials been received. It is then recommended to increase immediately the duration of the RSS process, and perform a new test to determine the new optimum duration of the screening process. If the screening process is monitored continuously, the time to each failure is known and the new and shorter optimum duration of the RSS process can be determined immediately without a new test (see IEC 61163-1 and IEC 61163-2).

If the failure level decreases significantly (a P-control chart can be used, see ISO 8258), the flaw intensity has probably been reduced by "debugging" of design, processes and/or selection of better components or raw materials. It is then recommended to perform a new test to determine the new and shorter optimum duration of the screening process. If the screening process was monitored continuously, the time to each failure will be known, and the new and shorter optimum duration of the RSS process can be determined immediately without a new test.

15.6.2 Data collection

This process involves

a) identification of the different types and associated quantities of hardware items exposed to the screening process;

b) identification of all the relevant and non-relevant failures;

c) classification of the relevant failures into three categories:

  - failures due to inherent flaws;
  - failures due to process induced flaws;
  - failures due to inadequate design;

d) identification of the conditions in the screening process at the time when the failures occurred;

e) identification of the application level of the screening process where the failures occurred;

f) recording of time or cycles to failure;

g) retain removed components or parts for future autopsy;

h) photograph of failure or fault (e.g. solder joints) prior to failure investigation or repair.

15.6.3 Failure analysis

An analysis of the collected data should be performed to ensure consistency with screening process objectives and goals. The analysis will be aimed at finding the source of flaws, be they component or material related flaws, process induced flaws or inadequate design flaws. The analysis will also be aimed at evaluating the post-screening process flaw density, and comparing it to the original screening process goals for flaw density. The results of the failure analysis should also be used to initiate corrective actions for the improvement of components, processes and design.

15.6.4 Corrective actions

When the collected screening process data of relevant RSS failures indicates that the original goals were too pessimistic or optimistic, corrective actions should be implemented. If there is also an indication that there are a large number of non-relevant failures, more effort should be made to try to eliminate these failures by conventional means other than the screening process, such as testing, inspection, process improvement and control or others. Screening process strength and parameters should also be re-tailored towards achieving the original objectives and goals.

Targeted corrective actions should also be taken to improve components, processes and design.

Annex A
(informative)

RSS of repairable items produced in lots

A.1 General

This annex provides an example of an RSS of repairable items produced in lots, based on Annex H of IEC 61163-1.

The item under consideration is a printed circuit board assembly (PBA) equipped with 175 components. It serves as a subsystem in a new product, and has been designed in accordance with the manufacturer's standard design rules. The components in use are well known by the designers from experience with previous products aimed for roughly the same market and end users. The field conditions can be characterized as stationary indoor use. Under working conditions the product will not be exposed to significant levels of vibration and shock. The temperature and humidity are maintained within limits suitable for the comfort of personnel in the same room. The PBA has been designed for correct functioning within an ambient temperature range from 5 °C to 70 °C. It is decided to screen on subassembly level i.e. screen the PBAs (see figure A.1).

A.2 Step 1 – Identification of objectives and goals

From previous experience, it is known that CMOS integrated circuits (ICs) and power transistors exhibit early failures, due to flaws in the components. In the present PBA, there are 16 ICs and eight power transistors among the total 175 components. The ICs, as well as the transistors, are plastic incapsulated.

The purpose of the RSS process is to ensure that the maximum percentage of weak items on the market is less than 2 %.

Since the RSS will be made on a repairable item (PBA) produced in lots, IEC 61163-1 is used.

A.3 Step 2 – Screening process design and application

Potential candidates for the screening process in this example (see figure 1) are as follows:

- constant high temperature;
- temperature cycling;
- fixed frequency sinusoidal vibration;
- swept frequency sinusoidal vibration;
- random vibration;
- bump;
- constant operational stress;
- operational stress cycling;
- constant high temperature and humidity;
- high humidity and temperature cycling;
- a combination of the above stresses, for example: temperature cycling and constant operational stress.

The temperature limits of all components on the PBA are within the range of –10 °C to +70 °C. The lower and upper temperatures were chosen accordingly. The rogue components have rather small dimensions, so a reasonably high rate of temperature change has to be used. It was chosen to be 5 °C per minute. The transition time then becomes approximately 15 min. The dwell time at the lower temperature was chosen to be 30 min and at the higher temperature 1 h 30 min. During the whole cycle, the PBAs are operationally stressed corresponding to the maximum ratings for the PBA.

A functional testing in each cycle is performed at the end of the high temperature phase. The total duration of one cycle adds up to 2 h 30 min.

The following stress conditions and RSS cycle are chosen:

Lower temperature:	–10 °C
Upper temperature:	70 °C
Rate of temperature change:	5 °C/min
Dwell time:	at lower temperature, 30 min at upper temperature, 1 h 30 min
Constant operational stress:	maximum rated
Monitoring:	type B every 2 h 30 min.

A.4 Step 3 – Cost benefit analyses

The best estimate is approximately 20 % weak PBAs (see H.2 of IEC 61163-1). The maximum acceptable percentage of weak items on the market is 2 %. RSS is therefore required until the 20 % weak assemblies have been reduced to under 2 %.

A.5 Step 4 – Preparation of a screening plan

A screening plan is worked out describing the elements listed below.

Since the RSS will be made on a repairable item (PBA) produced in lots, IEC 61163-1 is used.

a) The factory manufacturing the PBAs is responsible for the RSS process. The person responsible is the foreman for the final adjustment and control. The normal testing equipment for the final control of the PBAs is used for the RSS. Personnel from the environmental testing laboratory operate the RSS chamber.

b) The failure modes and mechanisms that may appear are as follows (see H.2 of IEC 61163-1):

   For the ICs

   - partial damaging of the internal dielectric barriers due to ESD in the production handling;
   - formation of cracks in the plastic encapsulation due to a difficult manual production process.

For the transistors:

- formation of cracks in the plastic encapsulation due to a difficult manual production process.

c) The RSS programme will continue until the average percentage of weak PBAs over four weeks is below 2 %.

d) The PBAs are screened after final adjustment and final testing, but before they are mounted in the system. The same test equipment is used after the RSS process as for the final control.

e) The screening process is therefore on a subsystem level.

f) The RSS cycle described under step 2 is used.

g) Describing the rationale behind the selection of the important parameters for the selected screening process.

h) The PBAs on RSS are monitored every 2 h 30 min (see figure 2, type B). Further, the percentage of failures at the final testing equipment after the RSS process is collected and the running average over four weeks is computed.

   A failure analysis is made for all failures and corrective actions in processes, components and design initiated.

   A Shewhart control P-chart according to ISO 8258 is made. If the weekly percentage of failures is below the lower control limit (LCL), data from the RSS process is analyzed in order to reduce the duration of the RSS process.

   If the weekly percentage of failures is above the upper control limit (UCL), the duration of the RSS process is immediately doubled. The new (and longer) optimum duration is computed on the basis of data from the RSS process monitoring.

i) Weibull probability paper is used as described in annex F of IEC 61163-1.

j) As soon as the average percentage of failures during and after the RSS process is below 2 % the 100 % RSS process is discontinued. A sample of 10 PBAs is collected every day from production. When 50 PBAs have been sampled they are placed in the RSS process. If there are more than two failures in two consecutive weekly samples (more than two failures in 100 PBAs) then 100 % RSS is immediately reintroduced.

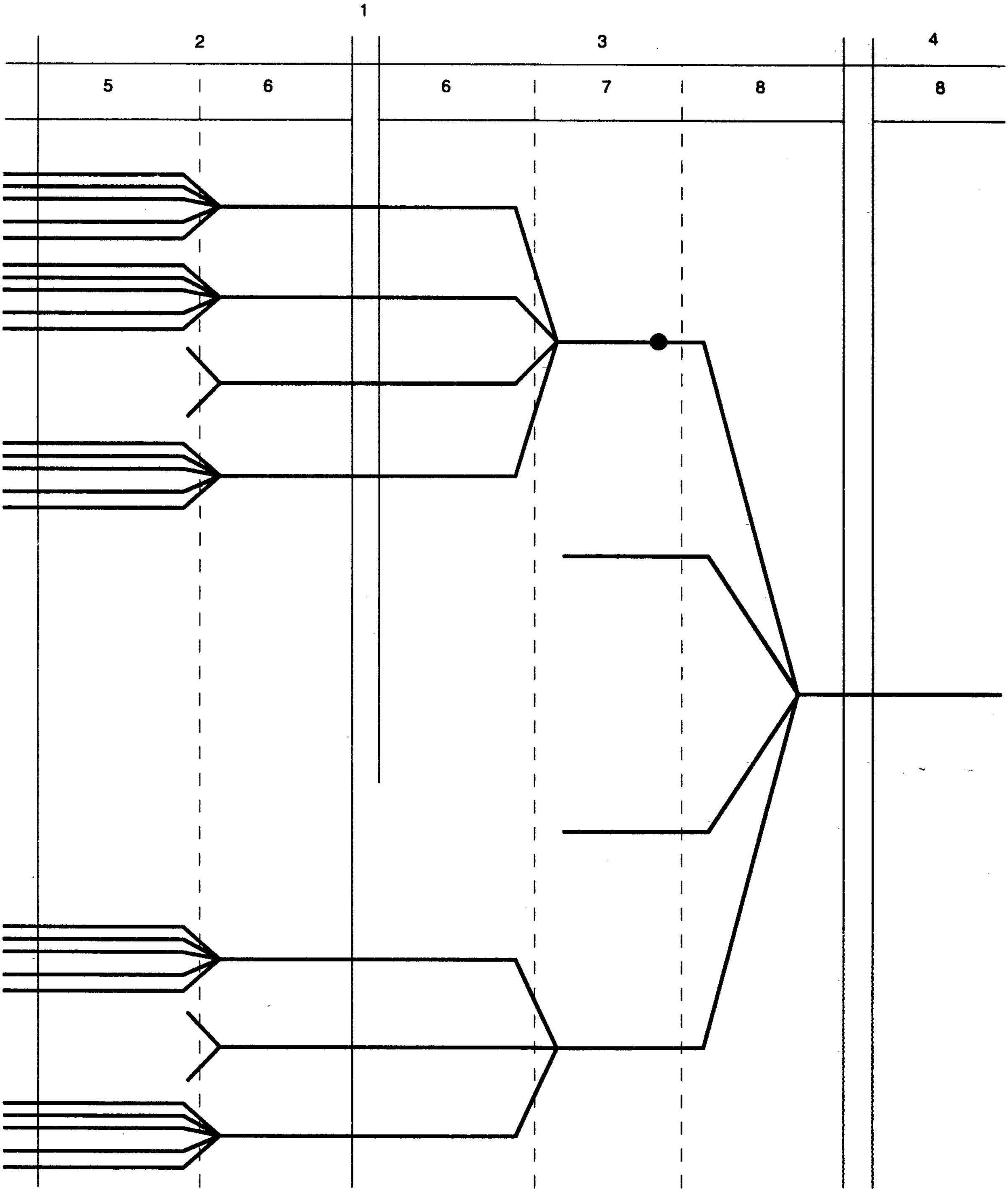
The RSS on sample basis is discontinued when the percentage of failures in the sample RSS process has for three consecutive months been below 1 %.

A.6 Step 5 – Screening process data collection, analysis and corrective actions

A pilot production run of 100 PBAs goes through the planned RSS process as a test RSS.

The duration of the RSS test is chosen to be 134 cycles, which corresponds to about two weeks, in order that all weak PBAs fail during the test RSS.

The failure data is then plotted on Weibull probability paper (see H.3 of IEC 61163-1) and the optimum duration of the RSS process computed to be 12 cycles (30 h). The RSS process is then performed on all PBAs produced (100 % RSS) for four months. After this, RSS on a sample basis is introduced. After six weeks, production problems cause 100 % RSS to be reintroduced for two months. One year after the start of production, sample RSS is finally discontinued for this product.



1) Screening laboratory
2) Component manufacturer
3) System manufacturer
4) End user
5) Material level
6) Component level
7) Subsystem level
8) System level

Figure A.1 – Level chosen for the RSS process

Table A.1 – Relation between the sensitivity of flaws and stresses

FLAWS STRESSES	– Cracks in power transistor encapsulation due to a difficult manual production process	– Cracks in CMOS IC encapsulation due to a difficult manual production process	– Partial damaging of CMOS ICs due to ESD in production handling	REMARKS
Constant high temperature			X	Usable
Low/high temperature cycling	X	X		Usable
Fixed frequency sinusoidal vibration				The item is not designed for a rough mechanical environment
Swept frequency sinusoidal vibration				
Random vibration				
Bump				
Constant operational stress			X	Usable
Operational stress cycling	X			Usable
Constant high humidity and temperature	X	X		Suitable for screening, although not expected in field conditions
High humidity and temperature cycling		X	X	

Annex B
(informative)

RSS of electronic components

B.1 General

This annex gives an example of an RSS of electronic components, based on annex D of IEC 61163-2. The component is a standard catalogue bipolar silicon power transistor.

B.2 Step 1 – Identification of objectives and goals

The application of the component requires that the turn-on time be 0,5 μs and turn-off time be 1,0 μs at $I_C = 2$ A. According to the component data sheet the times are specified as typical data at $I_C = 5$ A. The use of this component type, with the special performance regarding the switching (pulse response) data, gives the equipment top performance, making it competitive on the market.

The component manufacturer is contacted, but cannot give any advice regarding the expected outcome of a screening operation and is not aware of anyone else who performs this kind of selection. He is not willing to perform the screening as the requested quantity is too low and any special arrangement during manufacturing designed to increase the ratio of "good" components is not possible for technical reasons.

The switching time decreases with increasing temperature. The temperature coefficient is not well defined. As the parameter is not measured at the outgoing control and has not been measured during the type test, nothing can be predicted with certainty about the stability of this parameter over time.

No rejects are accepted by the component manufacturer regarding components with parameters outside the user's criteria. Rejects are accepted only if specified data are outside the manufacturer's specified limit.

Since the screening will be made on component level, IEC 61163-2 is used.

B.3 Step 2 – Screening process design and application

From contact with the component manufacturer it is obvious that the screening should be performed by measuring the pulse response time at a low temperature operation, and also after some time at high temperature operation. The measurement will be performed with $I_C = 2$ A and V_{CC} and other data as in the current application. The high temperature screening will be performed with specified power applied.

The highest ambient temperature at the current place in the equipment is measured in prototypes and calculated to be +70 °C. This is lower than the specification value of 125 °C. Specified maximum power should be applied during screening to raise the junction temperature and increase the time acceleration. The specified lowest ambient temperature for the equipment is 0 °C and the measurement should therefore be performed at this temperature.

It is of vital interest to know the temperature coefficient of the parameters and also the stability over time. Therefore, the following sequence is initially performed as a baseline:

a) measurement and logging of the parameters at 0 °C ambient temperature;

b) measurement and logging of the parameters at room temperature;

c) high temperature operation screening at 125 °C;

d) measurement and logging of the parameters at room temperature.

It should however be borne in mind that if the temperature coefficient and the stability can be assured, the sequence could be reduced to measurement at room temperature only. It is therefore decided not to obtain a full set of screening and test equipment before a test screening is performed.

B.4 Step 3 – Cost benefit analyses

Prototypes have shown that it is not possible to use the component without screening. It is not possible to buy a component with the necessary parameters within an acceptable price range and time limit. Therefore RSS is necessary.

B.5 Step 4 – Preparation of a screening plan

A screening plan is worked out describing the elements listed below.

Since the screening is performed at component level, IEC 61163-2 is used.

a) The screening is performed by an independent laboratory offering such services.

b) Identification of the possible flaws and failure modes for the component was not necessary in this case.

c) The objective of the screening is to select the components that with a 99 % confidence fulfil the required pulse response.

d) Each component batch is screened as it is received from the component manufacturer. Approved components are sent to the equipment manufacturer.

e) In this case the screening is made at component level.

f) Measurements are made at room temperature and 0 °C. Accelerated ageing is carried out at +125 °C.

g) The communication with the component manufacturer is used to document the rationale for the selected screening process.

h) The pulse response parameters are measured at room temperature. Components outside the acceptance criteria are rejected. Then, the high temperature operation screening is performed at 125 °C. Data are then again measured and logged at room temperature. The drift is then calculated and the reject rate for the batch computed. Components with a drift above 50 %, or which are outside the acceptance criteria, are rejected. All batches with a reject rate greater than 10 % are rejected.

i) It was assumed that the data would approximately follow a bimodal distribution. A plot on Gauss probability paper showed this to be a fair assumption. The reject rate is a binomial distributed parameter.

j) The screening will have to continue for as long as the production runs (including the manufacturing of spare modules for repair). However, the screening process may be modified based on the results of the test screening and the data logged. Only if a very high degree of confidence is reached that no components are delivered with parameters outside the acceptance criteria can the measurement of the parameters be discontinued, as the values of the parameters are not guaranteed by the component manufacturer.

B.6 Step 5 – Screening process data collection, analysis and corrective actions

The results of the test screening made it possible to reduce the time for the high temperature screening and measurement at 0 °C could be deleted.

If experience from equipment manufacturing or from field use of the equipment shows that the parameters increase more with time than is experienced during the test screening, the time for the screening should be increased or possibly the criteria for batch reject modified. An evaluation should be performed before a decision is taken.

Information about the outcome of the test screening is given to the component manufacturer. He is also informed about the design of the screening sequence, of the reject criteria and about the result of the continued screening. The component manufacturer has no obligation to react, but the information could be valuable as it is of a common interest to supply components to a tighter specification and the user would expect higher rates of good components in the delivered batches.

As soon as confidence is reached that no batches with bad stability are delivered, the high temperature operation screening can be discontinued.

Only if a very high degree of confidence is reached so that no components are delivered with parameters outside the acceptance criteria can the measurement of the parameters be discontinued, as the values of the parameters are not guaranteed by the component manufacturer.

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